REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
October 31, 1995

3. REPORT TYPE AND DATES COVERED
Final, June 1993 - October 1995

4. TITLE AND SUBTITLE
Search for Higher Temperature Superconductors by Novel Approaches

5. FUNDING NUMBERS
1601/07
63218C

6. AUTHOR(S)
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AFOSR-TR-96

0148

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10. SPONSORING/MONITORING AGENCY REPORT NUMBER
F49620-93-1-0310

19960404 056

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Under the partial support of USAFOSR Grant No. F 49620-93-1-0310 by BMDO from June 1993 through October '95 the Principle Investigator, C. W. Chu, showed that superconductivity occurs at record high temperatures in mercury-based compounds up to 134 K and 164 K at ambient and high pressures, respectively, making it possible to operate superconducting devices in a space environment without the help of liquid coolant and on earth simply with the aid of household air-conditioner technology, and in a compound of Ba-Ca-Cu-O without toxic elements up to 124 K at ambient pressure. A demonstration experiment is under way in collaboration with the National Aeronautics and Space Administration (NASA). He was the first to make thin films of this class of compounds, demonstrating the possible attainment of superconducting electronics with superior performance. He demonstrated the feasibility of constructing an ultra-fast high-powered high-temperature superconducting switch with profound implications for the defense and civilian technologies. Many of the new and improved compounds resulting from the present study also enabled him to examine some crucial issues of high temperature superconductivity and to show that recent claims of superconductivity near room temperature are premature.

14. SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
UNCLASSIFIED

18. SECURITY CLASSIFICATION
UNCLASSIFIED

19. SECURITY CLASSIFICATION OF ABSTRACT
UNCLASSIFIED

20. LIMITATION OF ABSTRACT

DTIC QUALITY INSPECTED 1

FINAL REPORT

(June 1993 through October 1995)

to

Dr. Harold Weinstock
AFOSR/NE, 110 Duncan Avenue, Suite 115
Bolling AFB DC 20332-0001

Title: Search for Higher Temperature Superconductors by Novel Approaches

Funding Number: AFOSR C/F 49620-93-0310 by BMDO

by

C. W. Chu
Texas Center for Superconductivity
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October 31, 1995

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SUMMARY

Under the partial support of USAFOSR Grant No. F 49620-93-1-0310 by BMDO from June 1993 through October 1995, the Principle Investigator, C. W. Chu, showed that superconductivity occurs at record high temperatures in mercury-based compounds up to 134 K and 164 K at ambient and high pressures, respectively, making it possible to operate superconducting devices in a Space-environment without the help of liquid coolant and on earth simply with the aid of household air-conditioner technology, and in a Ba-Ca-Cu-O compound without any toxic element up to 124 K at ambient pressure. A demonstration experiment is under way in collaboration with the National Aeronautics and Space Administration (NASA). He was the first to make thin films of this class of compounds, demonstrating the possible attainment of superconducting electronics with superior performance. He demonstrated the feasibility of constructing an ultra-fast high-power high-temperature superconducting switch with profound implications for the defense and civilian technologies. Many of the new and improved compounds results from the present study also enabled him to examine some crucial issues of high temperature superconductivity and to show claims of superconductivity near room temperature to be premature.

I. RESEARCH OBJECTIVES

- To carry out a concerted search for superconductors with a transition temperature (T_c) above the record of 125 K in $Tl_2Ba_2Ca_2Cu_3O_{10}$, set in 1988, by adopting an empirical approach and, at the same time, taking advantage of the unusual expertise and capability in material synthesis and characterization of our group and of the Texas Center for Superconductivity at the University of Houston.
- To improve some existing high temperature superconductors (HTS's) for possible applications
- To perform feasibility studies on high temperature superconducting devices

II. ACCOMPLISHMENTS

- $HgBa_2Ca_{n-1}Cu_nO_{2n+n+\delta}$ [Hg-12(n-1)n or HBCCO] System
  - achieved record high T_c in HBCCO up to 134 K and 164 K at ambient and high (30 GPa) pressures, respectively, making it possible to operate HTS devices with passive cooling in Space or with air-conditioner technology on earth
  - synthesized the first Hg-1201 and -1212 films, demonstrating that HTS electronic devices can be made of the HBCCO compounds with superior properties, *e.g.* a $J_c = 10^6$ A/cm^2 has been achieved at 100 K; and a Hg-1212 SQUID was later successfully operated at 114 K by IBM
  - developed the solid-vapor processing technique to prepare pure samples of HBCCO at ambient pressure
  - determined structure of Hg-1212 by n-diffraction
  - determined magnetic properties of HBCCO and found a moderate flux pinning force in HBCCO, suggesting a significant application potential for these compounds
  - synthesized purest samples, to date, of Hg-12(n-1)n with n = 1, 2, 3, 4, 5, 6 under pressure, making it possible to address several critical issues concerning the occurrence of HTS
  - showed the needs for modifications of HTS-models proposed, by observing deviations from predictions of these models, *e.g.* the pressure and doping effects on the T_c's of HBCCO, the strong covalence bonding between Hg and O(4), and the unusual linearly coordinated Hg-ions

- Ba-Ca-Cu-O [BCCO] System
  - synthesized a superconducting layered BCCO compound with a T_c up to 124 K at ambient, the highest in any HTSs without toxic element

- RM_2B_2C with R = Y, Sc or a rare-earth element; M = transition metal elements
  - identified YPd_2B_2C as the phase responsible for the 23 K-superconductivity reported by AT&T Bell Labs
  - discovered $Y_2Ni_2B_2C_2$ to be superconducting at 3 K in contrast to expectation
  - determined the superconducting and magnetic properties of YPd_2B_2C, YNi_2B_2C, and $Y_2Ni_2B_2C_2$ at ambient and high pressures, demonstrating the small anisotropy in these compounds, and a large difference between the band-structures of the latter two compounds
  - synthesized RCo_2B_2C and RRh_2B_2C, neither is superconducting probably due to the strong magnetic effect of Co in the former and the large magnetic polarization effect of Rh in the latter

- Unidentified Superconducting Objects (USO's)
  - reproduced the resistive anomalies previously reported by J. T. Chen *et al.* in single-grain YBCO samples whose magnetic properties have yet to be determined

- observed resistive but not magnetic anomalies, reminiscent of a superconducting transition in HBCCO at temperatures ranging from 160 to 300 K which are not likely to be associated with the melting of Hg which occurs at 235 K
- observed magnetic but no resistive anomalies in one multi phased oxide sample near 300 K at 0 T and ~ 200 K at 5 T

- Ultra Fast High Power HTS Switches
  - overcome several major material and technical obstacles and demonstrated the workability of such HTS devices whose performance will be enormously enhanced when the materials developed in the program are used

IV. PUBLICATION LIST

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